WiFi-VLC Hybrid System

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Motivation and Background

- Overcoming limitations of crowded RF Spectrum - more and more users increasing every day
- Imagine a flashlight that is able to send a morse code signal - a further advancement in technology (VLC)
- Rapid adoption of LEDs - brighter future for Visible Light Communication (VLC)

The objectives of our project include:

- To implement a hybrid system of WiFi uplink and VLC downlink.
- With typical TCP and UDP connection, to evaluate download data rate and websites loading time of the implemented system and compare it with that of the traditional WiFi.

Goal of the Project

At the end of the project, we intend to have the following goals achieved:

- ❏ Able to transmit data through LED and receive the same data on the receiving end (to a photodetector)
- ❏ Increased throughput and high data rates in hybrid systems than conventional systems (WiFi)
- ❏ Build a prototype in laboratory demonstrating VLC-WiFi Hybrid System

Change in target feature set

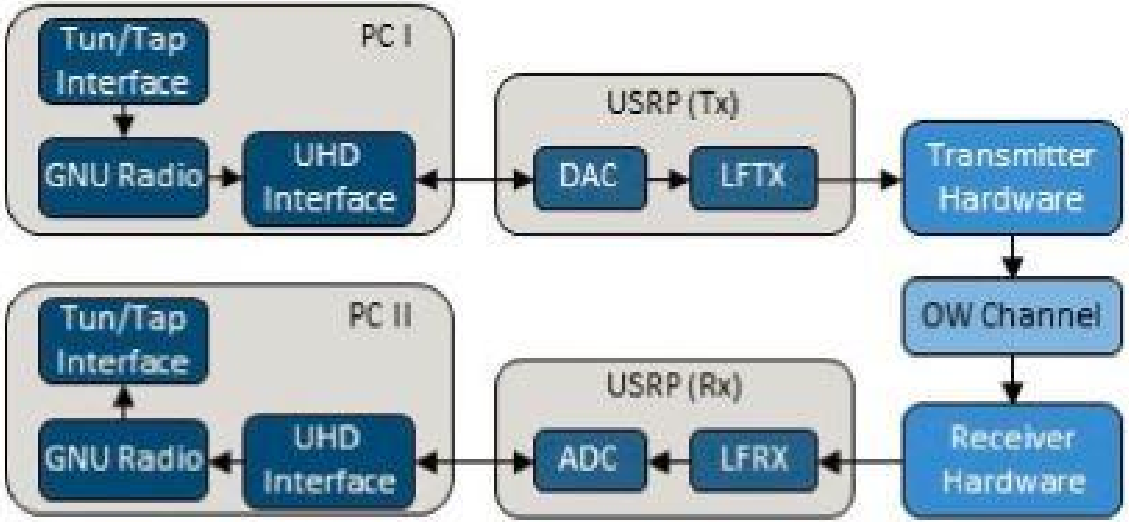
Initially we planned to make a 2-way visible light communication system. Due to limitations in the available laboratory hardware, we switched our project to a hybrid internet access system.

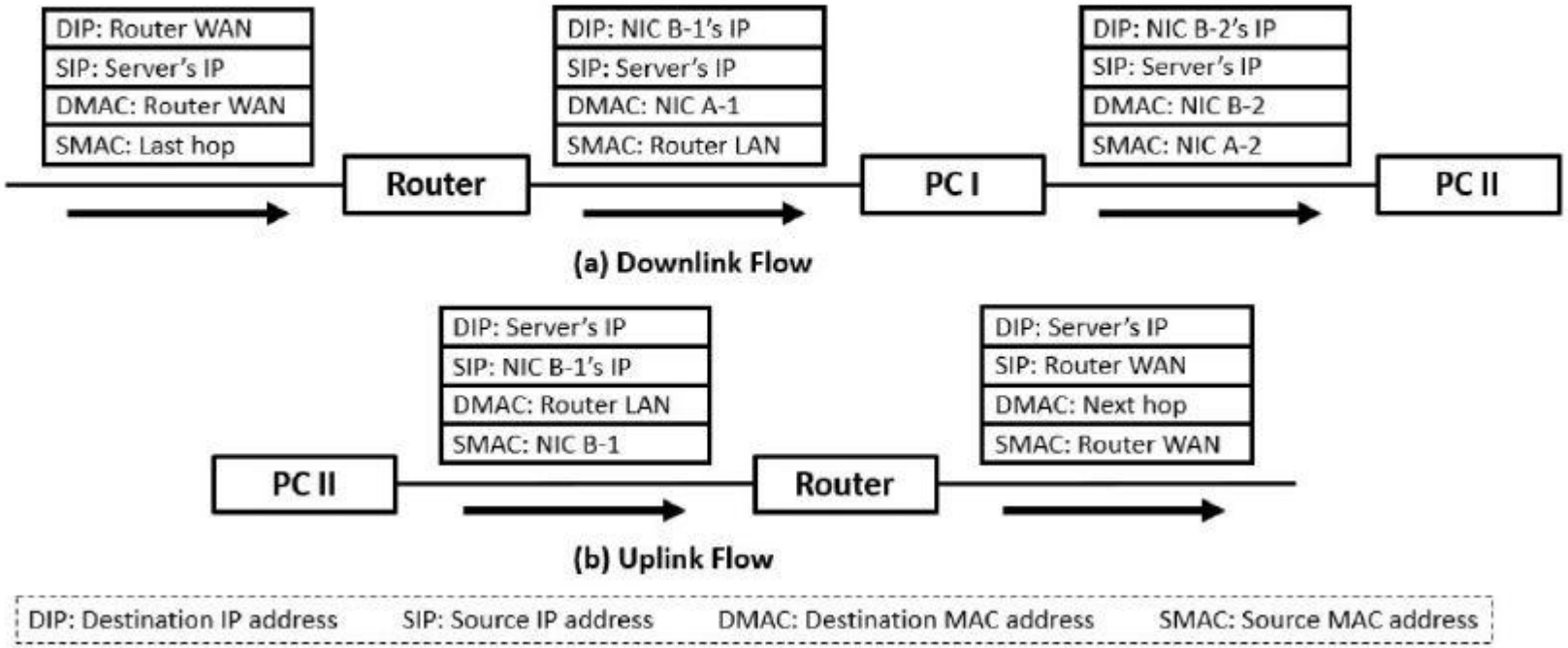
Our target for this project now is to demonstrate that it is possible to design a hybrid heterogenous system to access the internet on a PC.

Minimum Viable Product

A hybrid system prototype which allows 1 client PC to access the internet via a visible light downlink channel and a WiFi uplink channel.

The system will consist of 2 USRP (Universal Software Defined Radio Peripheral) devices, 1 WiFi router, 1 LED (transmitter), 1 photodetector (receiver), 1 relay PC, and 1 client PC.





"An Indoor Hybrid WiFi-VLC Internet Access System - IEEE Xplore Document", *Ieeexplore.ieee.org*, 2017. [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7035746. [Accessed: 18- Feb- 2017].

Work Division

Aneri	**Himanshu**	**Kaivalya**
Concept Map, Block Diagrams, System Architecture and Documentation	Simulation of SNR, Channel Gain and Receiver Power Distribution	Hardware setup including installation, configuration and interfacing

Note: This division is based on the work already done.

Current State of the Project

- ❏ Literature Study of Paper, Thesis and related articles
- ❏ Socket Programming Algorithm
- ❏ Interfacing transmitter and receiver hardware

We are currently establishing uplink VLC and interfacing components individually to understand the overall integration towards the end of the project.

Technical Risks

1) Hardware Failure
2) Obstruction (Non-Line of Sight) between transmitter and receiver
3) Poor performance in outdoor environments

Near-future Deliverables

By the next sprint review (25th March), we aim to achieve the following:

- Static routing, relay PC and client PC configuration
- Socket programming on relay PC
- Operating System spoofing on client PC
- Testing of Carrier Sense MAC OFDM with BPSK modulation on USRP using GNU radio’s tunnel.py

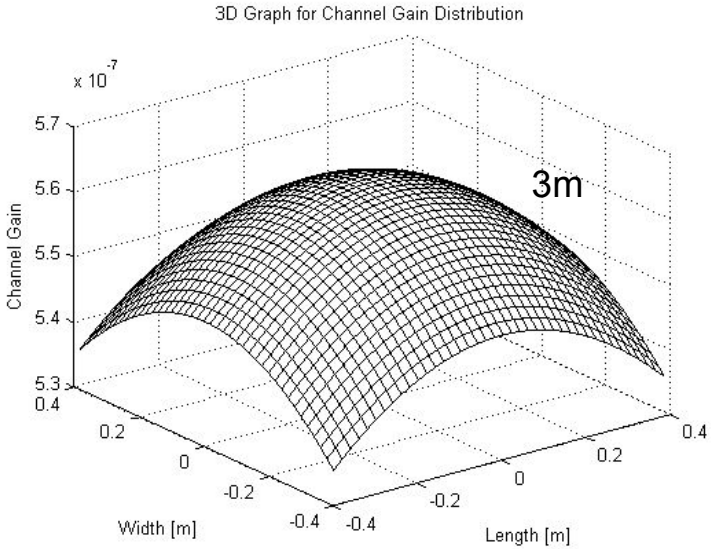
Results and Demonstration

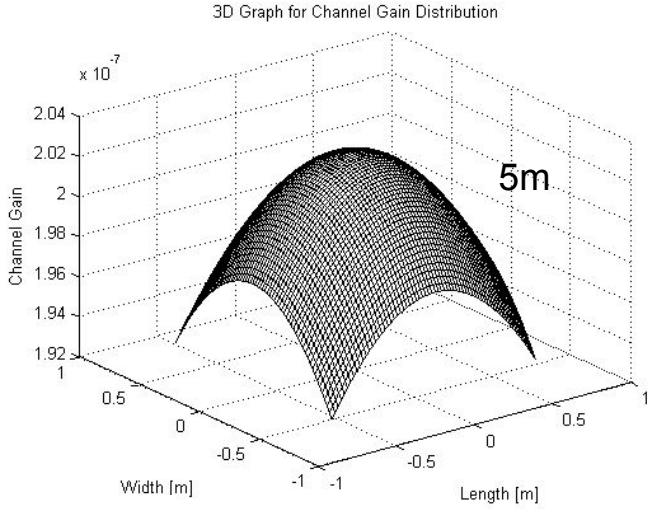
For 3 different distances between the Transmitter and the Receiver, we have the analytical plots of the following:

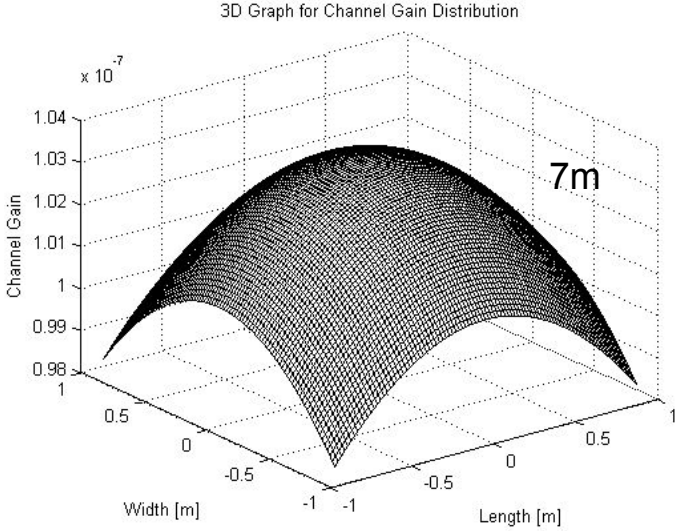
- ❏ Channel Gain
- ❏ Received Power
- ❏ SNR Distribution

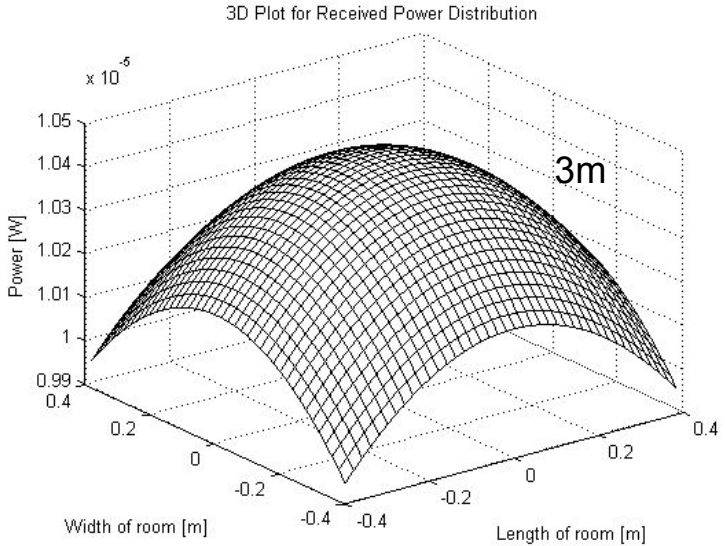
We have also shown the results of average download data rate for WiFi only and Hybrid VLC for comparison.

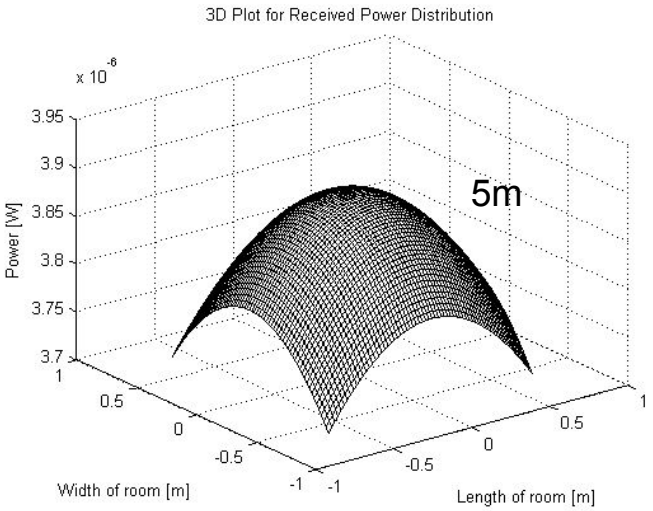
Reference: V. Communication, "Visible Light Communication - File Exchange - MATLAB Central", *In.mathworks.com*, 2017. [Online]. Available: https://in.mathworks.com/matlabcentral/fileexchange/53179-visible-light-communication. [Accessed: 03- Feb- 2017].

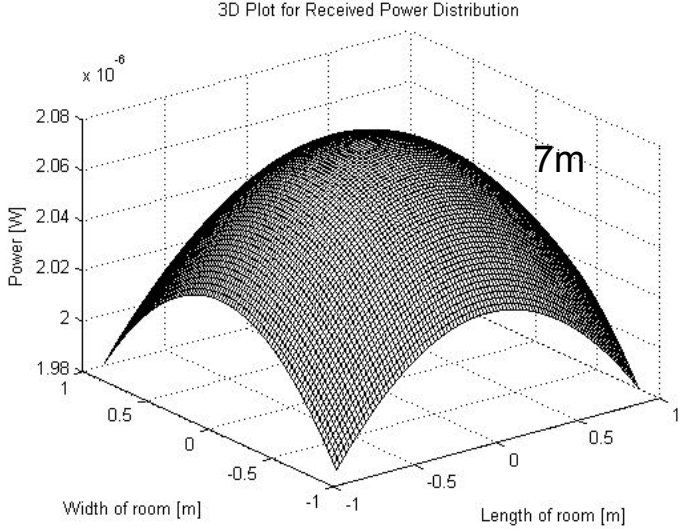

3D Graph for Channel Gain Distribution
x 10^-7
5.7
5.6
5.5
5.4
5.3
Channel Gain
3m
0.4
0.2
0
-0.2
-0.4
Width [m]
-0.4
-0.2
0
0.2
0.4
Length [m]

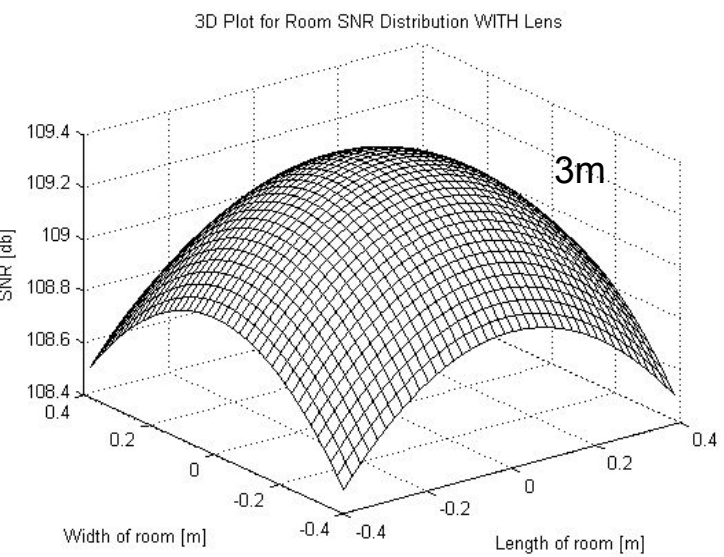

3D Graph for Channel Gain Distribution
x 10^-7
2.04
2.02
2
1.98
1.96
1.94
1.92
Channel Gain
5m
1
0.5
0
-0.5
-1
Width [m]
-1
-0.5
0
0.5
1
Length [m]

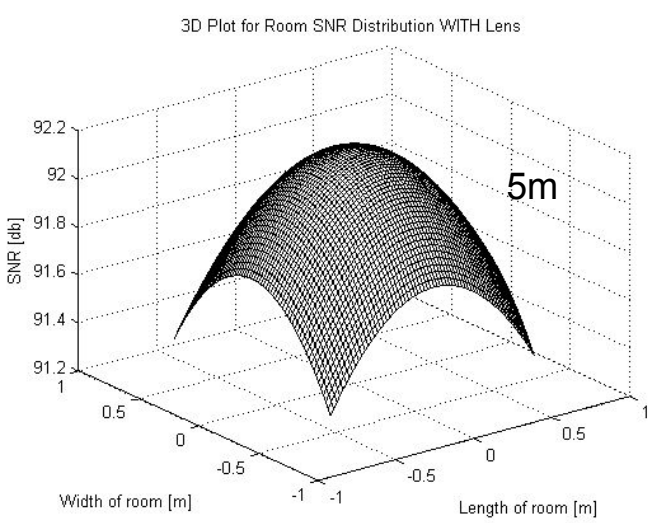

3D Graph for Channel Gain Distribution
x 10^-7
1.04
1.03
1.02
1.01
1
0.99
0.98
Channel Gain
7m
1
0.5
0
-0.5
-1
Width [m]
-1
-0.5
0
0.5
1
Length [m]

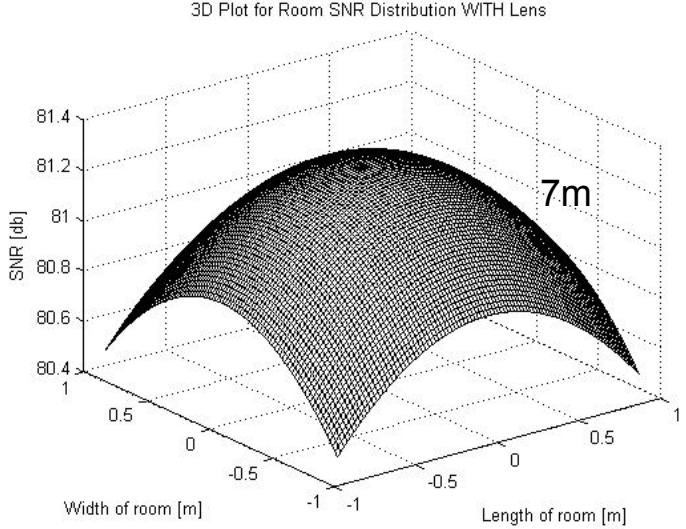

3D Plot for Received Power Distribution
x 10^-5
1.05
1.04
1.03
1.02
1.01
1
0.99
Power [W]
3m
0.4
0.2
0
-0.2
-0.4
Width of room [m]
-0.4
-0.2
0
0.2
0.4
Length of room [m]

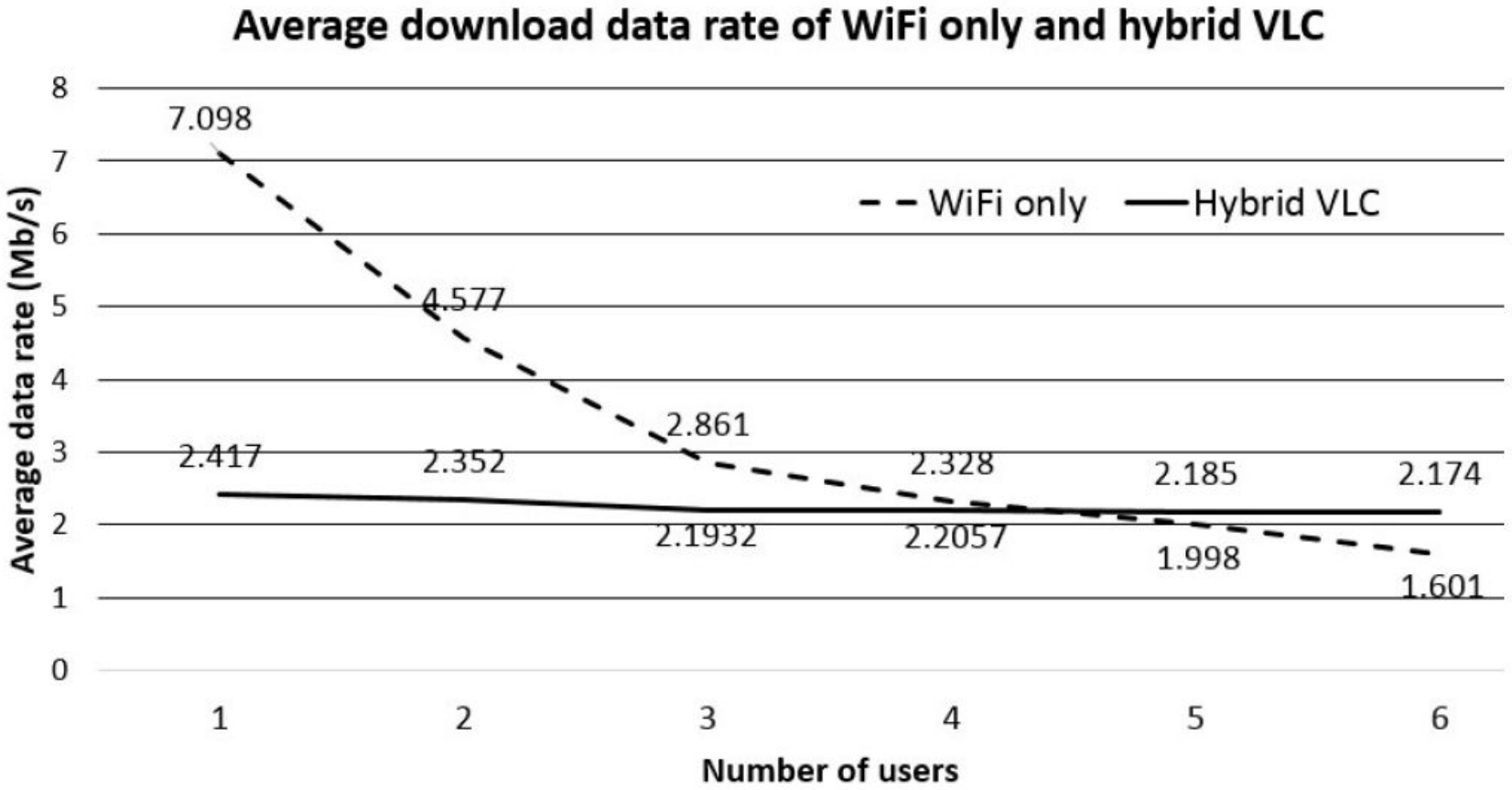

3D Plot for Received Power Distribution
x 10^-6
3.95
3.9
3.85
3.8
3.75
3.7
Power [W]
5m
1
0.5
0
-0.5
-1
Width of room [m]
-1
-0.5
0
0.5
1
Length of room [m]


3D Plot for Received Power Distribution
x 10^-6
2.08
2.06
2.04
2.02
2
1.98
Power [W]
7m
1
0.5
0
-0.5
-1
Width of room [m]
-1
-0.5
0
0.5
1
Length of room [m]


3D Plot for Room SNR Distribution WITH Lens
3m
SNR [db]
109.4
109.2
109
108.8
108.6
108.4
0.4
0.2
0
-0.2
-0.4
Width of room [m]
-0.4
-0.2
0
0.2
0.4
Length of room [m]


3D Plot for Room SNR Distribution WITH Lens
5m
SNR [db]
92.2
92
91.8
91.6
91.4
91.2
1
0.5
0
-0.5
-1
Width of room [m]
-1
-0.5
0
0.5
1
Length of room [m]


3D Plot for Room SNR Distribution WITH Lens
7m
SNR [db]
81.4
81.2
81
80.8
80.6
80.4
1
0.5
0
-0.5
-1
Width of room [m]
-1
-0.5
0
0.5
1
Length of room [m]



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Result Interpretation and Inference

From the above results that we have simulated using analytical equations, we conclude the following:

- The Channel Gain for a visible light channel decreases with increase in Transmitter-Receiver distance.
- The received power decreases with increase in Transmitter-Receiver distance.
- The Signal to Noise ratio decreases with increase in Transmitter-Receiver distance.
- The average data rate per user remains consistent with increase in number of users for a Hybrid VLC system.

Thank You